TRAVEL TIME IN GROUND WATER
SUMMARY OF CALCULATIONS

This document presents calculations of the time required for chemical species dissolved in ground water to travel from the plant to the property boundary (Indiana Street). The calculational method assumes only advective transport with no chemical/physical retardation.

PREDICTION OF TRAVEL TIME

<u>Alluvial Materials</u>

The travel time for a non-attenuated constituent to reach the property boundary in the Valley Fill Alluvium is in the range of 20 to 77 years. This is calculated as follows.

> The velocity is in the range of 170 to 650 feet per year, using either the grade of the base of the alluvium or the ground surface as the gradient (both equal 0.021), an hydraulic conductivity in the range of 8x10-4 to 3x10-3 cm/s, and an effective porosity of 0.1.
>
> A dissolved particle travels only a portion of this distance each year because the alluvium is not saturated for the full year. Assuming that the alluvium is saturated for about three-quarters of the year, the dissolved particle would travel approximately 130 to 490 feet during the year.
>
> The property boundary is approximately 10,000 feet from the source (distance between wells 64-86 and 1-86).

This calculation is considered conservative because the effective porosity is likely to be higher than the value used (as much as a factor of 3). Thus, the uncertainty regarding the effective porosity is more significant and tends to offset the correction for non-continuous saturation. Also, travel times are calculated for both the maximum and the average hydraulic conductivities. The travel time estimated using the average hydraulic conductivity is considered the most reasonable (77 years) because all reactive retardation processes are neglected in the calculations and, according to Mackay et al. (1985), the organic solvents of interest can be expected to migrate at rates two to three times slower than the ground-water velocity.

In addition, the calculation is extremely conservative because it neglects the travel time from the source to the Valley Fill Alluvium. For example, volatile organics in colluvial ground water at the 881 Hillside have moved approximately 200 feet (midway between wells 4-87 and 47-87) from the source near 9-74 in 15 to 18 years. Based on this velocity, it will require another 19 to 23 years before the organics travel the additional 250 feet to the Valley Fill Alluvium. Thus, organics from the 881 Hillside are not expected to reach the property boundary (well 1-86) for approximately 97 years (20 years in colluvium plus 77 years in Valley Fill).

<u>Bedrock Materials</u>

The travel time for a non-attenuated constituent to reach the property boundary in the Arapahoe sandstone is on the order of 800 years. This is calculated as follows.

> The velocity is approximately 12 feet per year, using an average hydraulic gradient of 0.03, hydraulic conductivity of 1x10-4 cm/s, and an effective porosity of 0.256 (Robson, 1983).
>
> The property boundary is approximately 10,000 feet from the subcrop of the sandstone.

This calculation assumes a sandstone horizon that is continuous for 10,000 feet. If such a sandstone exists, it would be 400 to 500 feet below ground at the property boundary, based on mapping presented in Robson et al. (1981). It is very unlikely that downgradient ground-water wells draw water from depths of 400 to 500 feet below ground, because data presented in Robson et al. (1981) indicate that adequate supplies (50 gallons per minute) can be obtained from depths of 100 to 200 feet below ground.

Travel Time in Ground Water
Summary of Calculations
February 13, 1989

SUMMARY

This document presents travel time calculations for ground-water transport of dissolved chemical species from the plant to off-site areas. The calculated travel times are as follows.

Alluvium	40 - 97 years
Bedrock	800 years

The calculations are conservative, using high values of hydraulic conductivity and neglecting travel time in the Rocky Flats Alluvium and colluvium; travel time in the colluvium was demonstrated to be significant at the 881 Hillside. In addition, the calculations neglect chemical processes (e.g., volatilization, degradation, adsorption, and precipitation) that can result in significantly longer travel time.

REFERENCES

Mackay, D.M., P.V. Roberts, and J.A. Cherry, 1985, Transport of Organic Contaminants in Groundwater, Distribution and Fate of Chemicals in Sand and Gravel Aquifers, ES&T Critical Review, Environmental Science and Technology, Volume 19, Number 5, pp. 384-392.

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